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Hydrographic conditions and mesozooplankton species distribution in the Bay of Biscay shelf during spring 2004

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Abstract

Mesozooplankton community structure on the southern Bay of Biscay shelf and its relationship with environmental conditions was analysed during spring 2004. According to thermohaline characteristics, we observed two frontal zones along the shelf (around 7° and 3°W) that gave rise to three distinct hydrographic regions. The westernmost part of the shelf (WC), defined by the presence of relatively warm and salty water related to the presence of the Iberian Poleward Current (IPC), the easternmost region (EC), characterised by colder and fresher water, and a region in the Central Cantabrian Sea (CC) with thermohaline characteristics in between these two extremes. Besides, a clear coastal-offshore pattern was found in relation to the mixed layer depth (MLD). We observed a good agreement between the aforesaid hydrographic regions and the distribution of zooplankton species. In the WC region, the community structure was dominated by *Paracalanus parvus*, *Oithona helgolandica*, *Acartia clausii* and *Clausocalanus pergens*, while in the EC region the most dominant species were *Noctiluca scintillans* and *Oncaea media*. The CC region showed similar composition of copepods than the WC region but larvaceans (*Oikopleura* and *Fritilaria*) were also abundant. Superimposed to this along-shelf pattern, relative abundances differed also between coastal and shelf stations.

1. Introduction

Mesozooplankton is a key component of the food web, channelling matter and energy from the lower to the higher trophic levels (Longhurst and Harrison 1989). As a component of the plankton ecosystem, mesozooplankton organisms are strongly controlled by environmental factors that affect their growth, reproduction and distribution (Mauchline 1998). This control could propagate up and down the different levels of the food web (Kiørboe et al. 1988; Munk et al. 1995), including different life stages of commercially important fishes stocks in the area, such as sardine, anchovy, mackerel and horse mackerel (OSPAR 2000 a).

Most of the studies on mesozooplankton composition in the southern Bay of Biscay are restricted to local (e.g. Valdés y Moral 1998) or meso-scales (e.g. Barquero et. Al 1998). Here, we present the data acquired during the *Pelacus* 2004 cruise, that was conducted in the continental shelf of the NW and N Iberian Peninsula between March 30 and April 22. As far as we know, this is the first comprehensive study on the distribution of mesozooplankton species during spring all along the southern Bay of Biscay shelf, from Galicia up to the French border. The wide spatial coverage allowed us to related the mesozooplankton distribution with the main hydrographic features characteristic of the sampled area during the winter-spring transition (OSPAR 2000 b).

2. Results and discussion

During the Pelacus cruise of 2004, a total of 98 CTDF (conductivity-temperature-depth-fluorescence) casts were carried out all along the shelf. In 61 out of these hydrographic stations, mesozooplankton samples were collected by means of a triple-ring WP2 net with 0.125 m^2 of mouth area and 200 µm mesh-size to obtain size-fractionated biomass and species composition. The distribution of environmental variables was obtained using an objective interpolation method (Haagenson 1982). The mesozooplankton species composition data-base was analysed by independent means.

Cluster analysis (Ward's method on the Euclidean distance matrix) was performed to obtain groups of samples (i.e. stations) with similar species composition. ANOVA and a *posteriori* Student-Newman-Keuls (SNK) test were used to asses the significance of the difference between cluster groups.

Hydrographic conditions in the southern Bay of Biscay during spring 2004 differed markedly along the shelf, allowing us to differentiate three distinct hydrographic regions. The westernmost part of the shelf (WC region) was characterised by relatively warm and salty waters (>13°C and 35.65) that denote the presence of the Iberian Poleward Current (Fig. 1 and 2). At the extreme of the sampled area, at the cul-de-sac of the Bay of Biscay (EC region), colder and fresher water was found (<12.5°C and <35.5) due to the influence of continental inputs and the different origin of water masses. In between these two zones, we observed a transitional area in the Central Cantabrian Sea (CC region). These regions are separated by two neat along-shelf fronts, the one located off Cape Estaca de Bares (around 7°W) that separates the WC and the CC regions, and the other located off Cape Machichaco (around 3°W) (Fig. 2). Besides, a distinct vertical mixing regime separated coastal from shelf stations, specially on the EC region (Fig. 3) where it gives rise to a notorious across-shelf front.

Phytoplankton biomass (as chlorophyll *a*) was relatively low (<1.5 $mg \cdot m^{-3}$) all along the shelf (Fig. 4), except in an spot in the southernmost stations, in the frontal area that separates the WC and the CC regions and in the across-shelf front in the EC region, where chlorophyll a concentration was 4-5 $mg \cdot m^{-3}$.

Mesozooplankton abundance varied between $2.4 \cdot 10^4$ and $50 \cdot 10^4$ $individuals \cdot m^{-2}$. A total of 118 mesozooplankton taxa were found, of which 61 were retained for further analysis. Cluster analysis on the mesozooplankton species abundance matrix (log $individuals \cdot m^{-2}$) allowed us to discriminate three major (distance level 50%) group of stations (Fig. 5, insert): cluster groups A, B and C (Table I). These cluster groups coincide to the zonation based on hydrographic characteristics. Each group showed significant differences (SNK test) in the relative abundance of the composition of the main species (Table II). Each of these groups could be further sub-divided (distance level 25%) in two sub-groups that separate between coastal and shelf stations (subscript 'c' and 's' respectively; Table I). Group A correspond with the WC region, characterised by the presence of the IPC. *Paracalanus parvus*, *Acartia clausii*, *Oithona helgolandica* and *Clausocalanus pergens* are the dominant species of this group. Group B, which corresponds with the transitional CC region, share with group A these dominant species, but with different relative abundance and also the characteristic presence of *Pseudocalanus elongatus* and larvaceans (*Oikopleura* spp. and *Fritilaria* spp.). Group C is characterised by the high abundance of *Noctiluca scintillans* (absence in the other groups), *Oncaea media* and *Temora longicornis*. The sub-division of each of these groups in a coastal and shelf sub-group ('c' and 's' respectively) is based on the high densities of *A. clausii* and meroplankton larvae found in the coastal domain.

2.1. Figures

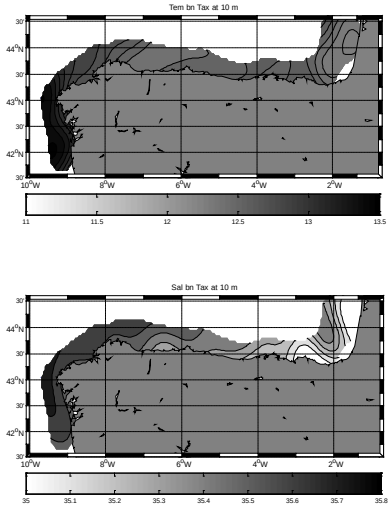
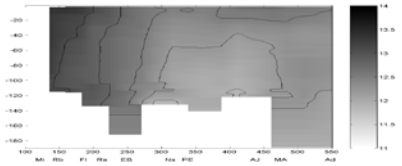


Figure 1. Spatial distribution of surface (10 m depth) temperature (top) and salinity (bottom).



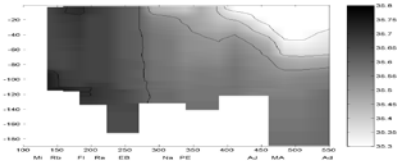


Figure 2. Along-shore section over the shelf (hydrographic stations with z > 100 m) running from 41.7°N, 9.5°W up to 44.5°N, 2°W. Labels at the bottom of the graph indicate the position of relevant geographic features (Mi, Miño river; Rb, Rías Baixas; FI, Fisterra Cape; Ra, Rías Altas; EB, Estaca de Bares Cape; Na, Nalón river; PE, Peñas Cape; AJ, Ajo Cape; MA, Machichaco Cape; Ad, Adour river)

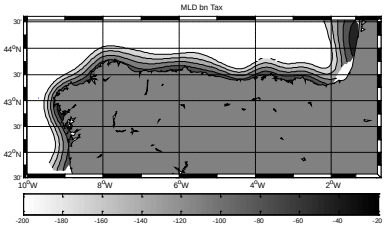


Figure 3. Spatial distribution of mixed layer depth (MLD) calculated according to $|\sigma_s-\sigma_{MLD}| > 0.04\cdot\sigma s$ (Durbin 2003), where σ_s is surface salinity and σ_{MLD} is the density at the MLD.

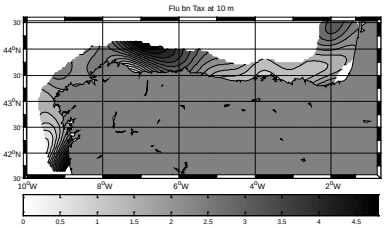


Figure 4. Spatial distribution of surface (10 m depth) chlorophyll a ($mg\cdot m^{-3}$).

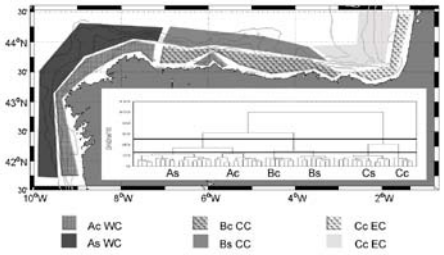


Figure 5. Geographical distribution of station groups (A, B and C; 'c' and 's' subscript refer to coastal or shelf station) defined by cluster analysis (insert graph) on mesozooplankton species composition. WC, CC and EC refer to the zonation based on hydrography.

2.2. Tables

Table I: The four most abundant species in each hydrographic region (AC, *Acartia clausii*; PP, *Paracalanus parvus*; OH, *Oithona helgolandica*; LCIR, cirripeda larvae; CLP, *Clausocalanus pergens*; PS; *Pseudocalanus elongates*; NOC, *Noctiluca scintillans*; OM, *Oncaea media*; TL, *Temora longicornis*). The percentage of relative abundance is given between brackets. The subscript 'c' and 's' denotes for coastal and shelf stations respectively.

Cluster group	Hydro. region	Ranked list of species
Ac	WCc	AC (28), PP (19), OH (15) LCIR (8)
As	WCs	PP (31), OH (25), CLP (15), AC (7)
Bc	CCc	AC (22), PP (18), OH (16), PS (7)
Bs	CCs	OH (32), PP (24), AC (9), CLP (8)
Cc	Ecc	NOC (51), OM (14), TL (8), AC (7)
Cs	Ecs	NOC (37), OH (17), PP (8), OM (6)

Table II. Comparison of the dominant species between cluster groups according to a multiple-range SNK test (note: '>' indicates a significant difference at $p < 0.05$, '=' indicates that the difference is non-significant, $p > 0.05$). Codes for the species and cluster group as in Table I (OIK, *Oikopleura* spp.; FRI, *Fritillaria* spp.)

Species	SNK test
NOC	Cs=Cc>Ac=As=Bs=Bc
PP	Ac>As=Bs=Bc>Cs=Cc
CCH	Ac=As>Bs=Bc>Cs=Cc
TL	Cc>Cs>Bc=Bs=As>Ac
AC	As=Bc>Ac=Bs=Cs=Cc
PS	As=Bs=Bc>Ac=Cs=Cc
OH	As=Bc>Ac=Bs>Cs=Cc
OM	Cc>Ac=As=Bs=Bc=Cs
OIK	Bc>Bs=Cc=Cs=As=Ac
FRI	Bs>Bc=Cc=Cs=As=Ac

3. Conclusions

Three different hydrographic zones along the shelf were obtained according to the distribution of thermohaline properties. These zones are separated by neat frontal areas.

Three major groups of stations were obtained according to the composition of mesozooplankton species. These major zonation could be further sub-divided to take into account the difference between coastal and shelf stations.

There was a clear coherence between the hydrographic zones and the distribution of mesozooplankton species assemblages. This is indicative of hydrographic control on the distribution of mesozooplankton in the Bay of Biscay shelf during the winter-spring transition.

4. Acknowledgments

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5. References

BARQUERO S., J.A. CABAL, R. ANADÓN, E. FERNÁNDEZ, M. VARELA and A. BODE (1998) Ingestión rates of phytoplankton by copepod size fractions on a bloom associated with and off-shelf front off NW Spain. *Journal of Plankton Research*, 20 (5): 957-972.

DURBIN, E.G., R.G. CAMPBELL, M.C. CASAS, M.D. OHMAN, B. NIEHOFF, J. RUNGE and M. WAGNER (2003) Interannual variation in phytoplankton blooms and zooplankton productivity and abundance in the Gulf of Maine during winter. *Marine Ecology Progress Series*, 254: 81-100.

HAAGENSON, P.L. (1982). Review and evaluation of methods for objective analysis of meteorological variables. *Papers in Meteorological Research*, 5: 113-133.

KIØRBOE, T., P. MUNK, K. RICHARDSON, V. CHRISTENSEN and H. PAULSEN. (1988). Plankton dynamics and larval herring growth, drift and survival in a frontal area. *Marine ecology Progress Series*, 44: 205-219.

LONGHURST, A.R. and W.G. HARRISON. (1989). The biological pump: Profiles of plankton production and consumption in the upper ocean. *Progress in Oceanography*, 22: 47-123.

MAUCHLINE, J. (1998). The Biology of Calanoid Copepods, In: *Advances in marine Biology, volume 33*, J.H.S. Blaxter, A.J. Southward and P.A. Tyler (eds.). Academic Press, 710 pp.

MUNK, P., P.O. LARSSON, D. DANIELSEN and E. MOKSNESS. (1995). Larval and small juveniles cod Gadus morhua concentrated in the highly productivity areas of a shelf break front. *Marine Ecology Progress Series*, 125: 21-30.

OSPAR Commission (2000 a). Quality Status Reprot 2000. OSPAR Commission, London. 108 + vii pp.

OSPAR Commission (2000 b) Quality Status Report 2000: Region IV –Bay of Biscay and Iberian Coast. OSPAR Commission, London, 134 + xiii pp.

VALDÉS L. and M. MORAL (1998) Time-series analysis of copepod diversity and species richness in the southern Bay of Biscay off Santander, Spain, in relation to environmental conditions. *ICES Journal of marine Science*, 55: 783-792.